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Bondarenko, Tatiana & Patrick D. Elliott. 2026. Monotonicity via mereology in the semantics of attitude reports. *Semantics and Pragmatics* 19(2). <https://doi.org/10.3765/sp.19.2>.

This version will be replaced with the final typeset version in due course.
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Monotonicity via mereology in the semantics of attitude reports*

Tatiana Bondarenko
Harvard University

Patrick D. Elliott
Heinrich-Heine University Düsseldorf

Abstract In this paper, we develop a new proposal about how the monotonicity of attitude verbs like *believe* should be modeled within the content-based approach to clausal embedding (Kratzer 2006, 2013a). We pursue the idea that monotonicity is a consequence of how the part-whole structure of attitudinal eventualities relates to the part-whole structure of their contents and thematic participants. In order to cash out this idea, we rely on a non-monotonic, equality-based implementation of the content-based approach (Moulton 2009, Elliott 2020, 2017, Bassi & Bondarenko 2021, Bondarenko 2022), supplemented with tools and concepts from mereology. We apply the mereological account of monotonicity to a pattern noticed by Sharvit (2024) concerning Negative Polarity Item (NPI) licensing in nominal arguments to monotonic attitude verbs, which existing implementations of the content-based framework fail to capture.

Keywords: clausal embedding, attitude reports, monotonicity, negative polarity items, mereology

1 Introduction

Monotonic attitude verbs like *believe* allow us to draw inferences such as from (1a) to (1b). At first blush, it seems that if a proposition p semantically entails a proposition q , then from x believing p we can infer that x believes q . How should such inferences be captured?

- (1) a. Katya believes that Anton snowboarded last Friday.
- b. Katya believes that Anton snowboarded.

* We're especially grateful to two anonymous reviewers for *Semantics and Pragmatics*, as well as to the handling editor Thony Gillies, for insightful feedback which greatly improved this paper. We'd also like to thank audiences at the following venues, where previous iterations of this work were presented: *Philosophical Linguistics and Linguistical Philosophy* (PhLiP) 8 in Westchester, the Heinrich-Heine University Düsseldorf *Meaning in Language Colloquium*, the *Bochum Language Colloquium*, Harvard University, *North East Linguistics Society* (NELS) 54 at MIT, *Complement Clauses Côte d'Azur*, and the *Nature of the Objects of Thought and Assertion* conference in Glasgow. Finally, Filipe Hisao Kobayashi, Vincent Rouillard, and Yael Sharvit provided useful discussion at various stages.

The predominant answer in the literature, originating in Hintikka’s (1969) work, is that attitude reports are modal statements. Concretely, *x believes that p* states that *p* is true in all worlds compatible with the beliefs of *x*. This semantics guarantees closure under entailment for belief reports.

In this paper, we provide an alternative to this orthodox view, framed in terms of the content-based semantics for attitude reports originally proposed by Kratzer (2006, 2013a). Instead of positing a modal semantics for monotonic attitude verbs, closure under entailment will be captured by exploiting the part-whole structure of attitudinal eventualities such as *believings*. Concretely, we propose that believing eventualities have non-trivial parts, and that the part-whole structure of believings reflects the part-whole structure of their propositional contents. Informally, the inference in (1) follows because (i) the information conveyed by *Anton snowboarded* is part of the information conveyed by *Anton snowboarded last Friday*, and (ii) since Katya has a belief with content *Anton snowboarded last Friday*, a *part* of her belief is that *Anton snowboarded*.

In light of this proposal, we examine patterns of NPI licensing in embedded clauses, as NPIs are known to be sensitive to the monotonicity properties of their local environment (Fauconnier 1975, Ladusaw 1979, and many others). Our main empirical focus will be the contrast in (2), first noticed by Sharvit (2024): Sharvit observes that in negated belief reports, NPIs cannot be licensed in relative clauses modifying objects like *the rumor*, (2a), but they are licensed in complement clauses composing with such noun phrases, (2b).

(2) *Sharvit’s Observation*

- a. *Katya doesn’t believe [the rumor [that Anton has ever spread]].
- b. Katya doesn’t believe [the rumor [that Anton has ever snowboarded]].

The data in (2) are puzzling given that singular definite descriptions otherwise anti-license NPIs (Lahiri 1998, Guerzoni & Sharvit 2007, Gajewski & Hsieh 2014, Crnić 2019a). So it must be something about the semantics of clausal embedding that makes NPI licensing possible in these sentences. Once we have a new approach to modeling monotonicity — one that does away with modal semantics and appeals to mereological properties of contentful eventualities instead — we’ll be able to account for the contrast in (2).

This paper is structured as follows: in Section 2, we describe the theoretical landscape emerging from the content-based approach to clausal embedding. We’ll introduce two variants of this view which we will go on to compare throughout the paper: one that maintains aspects of Hintikka’s modal semantics, which we call *Subset Semantics*, and one which does away with the modal component entirely, which we call *Equality Semantics*. Section 3 introduces our assumptions about the

licensing of weak NPIs, and outlines the predictions of subset vs. equality semantics. As we will see, neither version of the content-based approach as stated makes correct predictions regarding Sharvit’s observation. Section 4 presents our proposal about modeling monotonicity of attitude verbs like *believe*. We argue that there are certain constraints on the mapping between believings, their propositional contents, and their thematic participants. Crucially, we’ll make use of the idea that both attitudinal eventualities and their contents have a non-trivial part-whole structure. In Section 5 we show how our proposal for deriving monotonicity allows us to capture Sharvit’s observation. Section 6 is devoted to extensions and open issues: closure under conjunction, refining informational parthood, and discussion of Sharvit’s conclusions based on the NPI data. Section 7 concludes the paper.

2 The semantics of clausal embedding

In an influential series of lectures Kratzer (2006, 2013a,b, 2014, 2022) developed a new, compositional approach to the semantics of attitude reports. On Kratzer’s view, modal displacement is factored out of the lexical semantics of attitude verbs, and is instead encoded in the semantics of embedded clauses. Couched within *event semantics* (Davidson 1967), this approach models the semantic contribution of *believe* as simply contributing a believing eventuality, as in (3).¹ Note, that we adopt a neo-Davidsonian rendering (following, e.g., Elliott 2016, 2017), according to which all arguments are severed from the verb (Castañeda 1967). Argument composition is mediated by *thematic functions*; for example, the attitude holder is introduced via a partial function *HOLDER*, which maps believings to their holders.²

$$(3) \quad \llbracket \text{believe} \rrbracket = \lambda e_v. \text{believe}(e)$$

¹ We use the term *eventuality* to cover both events and states (Bach 1986).

² In the following, we make use of technology from both event semantics, and intensional semantics (see, e.g., von Stechow & Heim 2023), therefore we need to be explicit about the relationship between eventualities and possible worlds. Although we don’t believe that anything crucial hinges on this, for concreteness we do not assume *transworld* eventualities (cf. Lewis 1987); rather, we assume that possible worlds are maximal eventualities (Fine 2017c). Consequently, eventualities are located in worlds. This justifies the fact that predicates of eventualities are not relativized to a world of evaluation; *believe*(*e*) is simply true of any possible eventuality (in any world) that is a *believing*. Following standard assumptions in event semantics, we posit an existential closure operator $\exists$ responsible for closing off the eventuality variable. We take $\exists$ to be responsible for locating the eventuality in the world of evaluation. $\exists e \leq w$ is to be understood as locating eventuality *e* in world *w*.

- (4) $\llbracket \text{Mitya believes that } \dots \rrbracket^w = 1 \text{ iff}$
 $\exists e \leq w [\text{HOLDER}(e) = \text{M} \wedge \text{believe}(e) \wedge \dots]$
There's an eventuality e located in w ,
that's a believing and whose holder is Mitya. . .

In the remainder of this section, we introduce two different sub-proposals concerning exactly how the semantics of the embedded clause should be implemented: *subset semantics* and *equality semantics*. Subset semantics, based on Kratzer's (2006) original proposal for the declarative complementizer, cleaves to the standard, modal view of attitude reports (Hintikka 1969), whereas equality semantics represents a more radical departure, factoring modality out of attitude reports altogether.

2.1 Subset semantics

One of Kratzer's main innovations is to mediate composition of embedded *that*-clauses via the content function: a (partial) function we will write as CONT .³ The role of CONT is to map *contentful* entities, such as believings, facts, stories, etc. to their informational contents, modeled as propositions; we therefore refer to Kratzer's decomposition approach more generally as the 'content-based approach'. Embedded *that*-clauses themselves are taken to be predicates of contentful entities.

Kratzer (2006) states declarative *that*-clause meanings in terms of semantic entailment between the output of the content function, and a proposition introduced by the embedded sentence (5) (see also Hacquard 2006); we call this semantics *subset semantics* (following Bassi & Bondarenko 2021). Composition may proceed by adopting a polymorphic type for *that*-clauses.⁴ This reflects the assumption that both eventualities and individuals may have propositional content, and are therefore in the domain of CONT . This flexibility will be exploited in order to account for the broader distribution of embedded *that*-clauses.

- (5) *Subset semantics for that-clauses* (after Kratzer 2006):
 $\llbracket \text{that } S \rrbracket = \lambda x_{\sigma} . \text{CONT}(x) \subseteq \{ w' \mid \llbracket S \rrbracket^{w'} = 1 \} \quad \sigma \in \{ e, v \}$

Minimally, it seems reasonable to assume that an attitude holder's doxastic alternatives⁵ are a subset of the contents of any of the attitude holder's individual

³ See also work by Pietroski (2000) and Moltmann (1989, 2013, 2014, 2020, 2025).

⁴ We take this to be a case of *underspecification* rather than ambiguity *per se*. Elliott (2017) simply assumes no type distinction between eventualities and individuals, but we instead cash this out in terms of polymorphism in order to remain neutral on the question of whether a type distinction is necessary. See also discussion in (Bondarenko 2022: 4.2, p. 244-245).

⁵ Following Hintikka (1969), x 's doxastic alternatives are the set of worlds compatible with what x believes.

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belief states, as stated in (6). This is because an attitude holder may be committed to more than any of their individual believings.⁶

(6) *Content of believings:*

$$e \leq w \wedge \text{believe}(e) \rightarrow \text{Dox}_w^{\text{HOLDER}(e)} \subseteq \text{CONT}(e) \quad \forall e \in D_v, w \in W$$

The result is a rather simple compositional semantics for belief reports. Since the attitude verb is of type $\langle v, t \rangle$, and *that*-clauses may be of type $\langle v, t \rangle$, the *that*-clause may compose with the verb via intersective modification. This is reminiscent of the standard treatment of adverbials in event semantics (Davidson 1967).⁷ The holder of the believing is integrated via a thematic function HOLDER, and the believing eventuality is finally existentially closed. The result is the Logical Form in (7).⁸

(7) $\llbracket \text{Mitya believes that it's raining} \rrbracket^w = 1$ iff

$$\exists e \leq w \left[\begin{array}{l} \text{HOLDER}(e) = \text{Mitya} \wedge \text{believe}(e) \\ \wedge \text{CONT}(e) \subseteq \{ w' \mid \text{it's raining in } w' \} \end{array} \right]$$

Subset semantics is a concrete implementation of the classical modal semantics for attitude reports (Hintikka 1969), in that it entails that the attitude holder's doxastic alternatives are a subset of the proposition denoted by the embedded *that*-clause. Subset semantics thereby predicts closure under entailment (8) for belief reports.⁹ This straightforwardly accounts for intuitively valid inferences from, for example, “Mitya believes that it's raining heavily”, to “Mitya believes that it's raining”.

(8) *Closure under entailment:*

For any sentences S, S' , attitude holder x ,
if S entails S' , then “ x believes S ” entails “ x believes S' ”.

⁶ Note that the attitude holder can always be retrieved from the attitudinal eventuality by making reference to the holder of the eventuality, assuming that all believings are in the domain of HOLDER.

⁷ This should not be taken to necessarily imply that embedded clauses are always syntactically adjuncts. We take it that a semantics based on intersective modification is independent of whether or not embedded clauses are syntactically selected for.

⁸ There are some non-trivial differences between the compositional regime we assume for embedded *that*-clauses in this paper, versus Kratzer's original proposal. Kratzer (2006) (see also Moulton 2009, 2015) assumes a rigid $\langle e, t \rangle$ type for *that*-clauses. Consequently, in order to compose with attitude verbs like *believe*, Kratzer assumes that the *that*-clause modifies an implicitly assumed individual argument via the composition principle RESTRICT (Chung & Ladusaw 2003). See Elliott (2016, 2017) for arguments that English *that*-clauses combine via the event argument of the verb, and (Bondarenko 2025a, Özyıldız 2020, Roberts 2021, Bochnak & Hanink 2022, Bondarenko 2022) for the view that embedded clauses can both be event modifiers and combine via the internal argument path.

⁹ A standard criticism of closure under entailment is that a rational agent may believe p without believing q , even if p logically entails q , simply by failing to recognize that p entails q . This problem in its full generality came to be known as *the problem of logical omniscience* (Stalnaker 1991). We'll put this problem aside for now (we will return to this issue in Section 6.3).

One of the virtues of [Kratzer’s](#) content-based approach to embedded clauses is that it accounts for their capacity to compose with NPs ranging over contentful entities, as well as their ability to serve as predicates in copular constructions (e.g., “the rumor is that it’s raining”). For example, assuming *rumors* are in the domain of CONT, the noun “rumor” can compose with *that*-clauses simply via intersective modification. As a result “rumor that it’s raining” denotes a property of individuals that are *rumors*, and whose content entails that it’s raining ([Kratzer 2006](#)).

- (9) $\llbracket \text{there's a rumor that it's raining} \rrbracket^w = 1 \text{ iff}$
 $\exists x \in w[\text{rumor}(x) \wedge \text{CONT}(x) \subseteq \{w' \mid \text{it's raining in } w'\}]$

On the face of it, subset semantics preserves many of the advantages of a classical modal semantics, while providing a uniform analysis of *that*-clauses in different environments.¹⁰ In the next section, we consider a different rendering of the content-based approach to embedded clauses which departs more radically from the standard modal view.

2.2 Equality semantics

Equality semantics is a version of the content-based approach which *equates* the content of a contentful entity with a proposition ([Moulton 2009](#), [Elliott 2017, 2020](#), [Bassi & Bondarenko 2021](#), [Bondarenko 2022](#)), (10).

- (10) *Equality semantics for that-clauses*
 (after [Moulton 2009](#), [Elliott 2017](#), [Bondarenko 2022](#), etc.):
 $\llbracket \text{that } S \rrbracket = \lambda x_\sigma. \text{CONT}(x) = \{w' \mid \llbracket S \rrbracket^{w'} = 1\} \quad \sigma \in \{e, v\}$

This small change results in a semantics that makes radically different predictions. Consider the resulting truth-conditions for a simple attitude report:

- (11) $\llbracket \text{Mitya believes that it's raining} \rrbracket^w = 1 \text{ iff}$
 $\exists e \leq w \left[\begin{array}{l} \text{HOLDER}(e) = \text{Mitya} \wedge \text{believe}(e) \\ \wedge \text{CONT}(e) = \{w' \mid \text{it's raining in } w'\} \end{array} \right]$

The resulting truth-conditions say, informally, that there’s a believing of Mitya’s, whose content is *that it’s raining*. This fails to deliver closure under entailment, because an attitude holder having a believing *e* with content *p* doesn’t say anything about whether the attitude holder has a believing *e'* with content *q*, irrespective of any semantic relationship between *p* and *q*.

¹⁰ It has also been exploited in recent accounts of phenomena such as mood and evidentiality. See, e.g., [Kratzer 2013a, 2016](#), [Bogal-Allbritten 2016](#), [Alonso-Ovalle](#), [Menéndez-Benito & Rubinstein 2024](#).

Despite this apparently serious failing, There are a number of arguments in favor of the equality semantics in the literature, including the impossibility of stacking multiple embedded clauses (Moulton 2009), copular constructions (Djäv 2019), the interpretation of clausal conjunction (Bassi & Bondarenko 2021), embedded clauses as complements to nouns under emotive verbs (Bondarenko 2025b), and polarity subjunctives (Bondarenko 2022). Below we focus on a version of an argument first suggested by Elliott (2017), concerning the interaction between embedded clauses and definiteness. This will later have ramifications for our main proposal.

Let us assume a standard Fregean semantics for the definite article, (12), and examine the predictions of subset vs. equality semantics for definite descriptions involving the content noun *fact*.

$$(12) \quad \llbracket \text{the} \rrbracket = \lambda P_{\langle e,t \rangle} : \exists! x[P(x) = 1] . \iota x[P(x) = 1]$$

Consider the different presuppositions predicted by each theory, outlined below:

(13) “the fact that it’s raining”

- a. Presupp. (subset): $\exists! x[\text{fact}(x) \wedge \text{CONT}(x) \subseteq \{w' \mid \text{it's raining in } w'\}]$
- b. Presupp. (equality): $\exists! x[\text{fact}(x) \wedge \text{CONT}(x) = \{w' \mid \text{it's raining in } w'\}]$

Subset semantics (13a) predicts that the definite description presupposes the existence of a *unique* fact, the content of which entails that it’s raining. Importantly, this presupposition is not satisfied if there are two abstract *fact* entities, Fact_r and Fact_{rh} with the following contents, (14), since the contents of both facts entail that it’s raining.

- (14) a. $\text{CONT}(\text{Fact}_r) = \{w' \mid \text{it's raining in } w'\}$
- b. $\text{CONT}(\text{Fact}_{rh}) = \{w' \mid \text{it's raining heavily in } w'\}$

This seems strange, given that in a context where it’s common ground that it’s raining heavily, a speaker can assert, for example, “the fact that it’s raining doesn’t bother me”. Nevertheless, perhaps a proponent of subset semantics can insist that either Fact_r and Fact_{rh} exist, but not both. After all, the ontological status of abstract entities such as *facts* is obscure—it’s difficult to be sure whether or not they exist, even if their contents are true. This perspective isn’t tenable however, given the acceptability of sentences such as (15). (15) presupposes that *there is a unique fact whose content entails that it’s raining*, and *there’s a unique fact whose content entails that it’s raining heavily*. For the presuppositions to be satisfied, the definite descriptions must in fact pick out the same fact—call it f . The assertion ascribes contradictory properties to f —that it both bothers and doesn’t bother the speaker. Therefore, subset semantics predicts (15) to be trivial, contrary to fact.

- (15) [The fact that it's raining] doesn't bother me,
but [the fact that it's raining heavily] really does.

Note that equality semantics doesn't face this problem — the equality semantics in (13b) simply predicts that (15) presupposes the existence of a unique fact whose content is *that it's raining*, and a (distinct!) unique fact whose content is *that it's raining heavily*. Subset semantics on the other hand 'collapses' "the fact that *p*" and "the fact that *q*" just in case there is an entailment relationship between *p* and *q*. In a sense, the predictions of subset semantics are reminiscent of what we expect for definite descriptions with ordinary intersective modifiers. The unacceptability of (16) is expected, since if the presupposition of "the student" is satisfied, then it and "the French student" must refer to the same individual. This problematic predictions of subset semantics will actually be central to why it can't account for the NPI licensing facts, as we discuss in the next section.¹¹

- (16) #The student doesn't bother me, but the French student really does.

To sum up, we've discussed two implementations of the idea that displacement is severed from the attitude verb and originates in the embedded clause. Subset semantics involves a more minimal departure from the classical Hintikka semantics: the relation established between the content of an eventuality and the embedded proposition is *subsethood*. Equality semantics instead proposes to treat CONT as a function which *equates* the content of an event with the embedded proposition.

3 NPIs and monotonicity

3.1 NPI-licensing and singular definite descriptions

An influential idea regarding NPIs posits that licensing relates to the *monotonicity* of the local environment.¹² This makes NPI licensing an ideal testing ground for theories of attitude reports that have direct implications for monotonicity. In order to assess these predictions, and especially since we will be looking at cases which involve definite descriptions, we adopt von Fintel's (1999) proposal that monotonicity should be computed relative to a kind of entailment that takes presuppositions into account: *Strawson Entailment*. In (17), we give a generalized definition of Strawson entailment for any boolean type τ (von Fintel 1999, Crnič 2019b).¹³ The basic idea

¹¹ The problematic predictions of subset semantics are not amnestied by adopting a more sophisticated semantics for definiteness, for example, one based on *maximal informativity* (von Fintel, Fox & Iatridou 2014).

¹² Fauconnier 1975, 1978, Ladusaw 1979, 1980b,a, Hoeksema 1986, Kadmon & Landman 1993, Lahiri 1998, von Fintel 1999, Crnič 2019b,a, and many others.

¹³ A type τ is *boolean* just in case $\tau = t$, or $\tau = \langle \sigma_1, \sigma_2 \rangle$, where σ_1 is any type, and σ_2 is a boolean type (Winter 2002).

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is as follows: for any boolean functions f and g , f Strawson entails g *iff* whenever an argument x satisfies the presuppositions of g , $f(x)$ entails $g(x)$.

(17) *Strawson Entailment* ($\Rightarrow_s$):

$$p\tau \Rightarrow_s q\tau \text{ iff } \begin{cases} p = 0 \text{ or } q = 1 & \tau = t \\ \forall x \in \text{Dom}(g), f(x) \Rightarrow_s g(x) & \tau = \langle \sigma_1, \sigma_2 \rangle \end{cases}$$

With this notion of entailment, we follow Crnič 2019b,a in defining the monotonicity properties of syntactic environments. The two properties we'll need are *Strawson Downward-Entailingness* (SDEness), (18a), and *Strawson Upward-Entailingness* (SUEness), (18b) (after Crnič 2019b: p.3, (7)).

(18) Given $S[X]$; X a subconstituent of S :

- a. S is *Strawson Downward-Entailing* (SDE) wrt X , iff:
For all constituents X' , s.t., $\llbracket X' \rrbracket \Rightarrow_s \llbracket X \rrbracket$, $\llbracket S \rrbracket \Rightarrow_s \llbracket S[X / X'] \rrbracket$
- b. S is *Strawson Upward-Entailing* (SUE) wrt X , iff:
For all constituents X' , s.t., $\llbracket X' \rrbracket \Rightarrow_s \llbracket X \rrbracket$, $\llbracket S[X / X'] \rrbracket \Rightarrow_s \llbracket S \rrbracket$

To illustrate, let's consider the sentences in (19) and (20). The whole sentence in (19) is SUE and not SDE with respect to its subconstituent $[_{NP} \text{ linguist}]$, the restrictor of the indefinite article. Any alternative NP whose denotation entails $\llbracket \text{linguist} \rrbracket$, for example, $\llbracket \text{syntactician} \rrbracket$, results in a sentence which entails (19), (19b), but is not entailed by it, (19c). Once we introduce negation into the sentence, (20), the whole sentence is SDE but not SUE with respect to its subconstituent $[_{NP} \text{ linguist}]$, (20b)-(20c), since if we substitute, for example, $\llbracket \text{syntactician} \rrbracket$, we'll get a sentence that does not entail the sentence in (20) but is entailed by it.

(19) $[_S \text{ Nadya met a } [_{NP} \text{ linguist}]]$.

- a. $\llbracket \text{syntactician} \rrbracket \Rightarrow_s \llbracket \text{linguist} \rrbracket$
- b. $\llbracket \text{Nadya met a syntactician} \rrbracket \Rightarrow_s \llbracket \text{Nadya met a linguist} \rrbracket$
- c. $\llbracket \text{Nadya met a linguist} \rrbracket \not\Rightarrow_s \llbracket \text{Nadya met a syntactician} \rrbracket$

(20) $[_S \text{ Nadya didn't meet a } [_{NP} \text{ linguist}]]$.

- a. $\llbracket \text{syntactician} \rrbracket \Rightarrow_s \llbracket \text{linguist} \rrbracket$
- b. $\llbracket \text{Nadya didn't meet a syntactician} \rrbracket \not\Rightarrow_s \llbracket \text{Nadya didn't meet a linguist} \rrbracket$
- c. $\llbracket \text{Nadya didn't meet a linguist} \rrbracket \Rightarrow_s \llbracket \text{Nadya didn't meet a syntactician} \rrbracket$

With the notions of SDEness and SUEness, we can now formulate the condition for licensing weak NPIs that we'll assume in this paper:

(21) *Licensing condition for weak NPIs*

A sentence containing a weak NPI α is acceptable *iff* α is dominated by a constituent that is SDE and not SUE with respect to α 's restrictor.

This licensing condition correctly predicts that, if we take (19) and (20), and replace the indefinite article *a* with NPI *any*, (19) won't be acceptable but (20) will be (assuming that *any* has the same semantic contribution as the indefinite):

- (22) a. *Nadya met any linguist.
 b. Nadya didn't meet any linguist.

The licensing condition as stated in (21) is actually stronger than is necessary for accounting for simple cases like (22), where simply requiring SDEness would be sufficient. The additional injunction against SUEness is motivated by the fact that weak NPIs are not licensed in singular definite descriptions (Lahiri 1998, Guerzoni & Sharvit 2007, Gajewski & Hsieh 2014, Crnič 2019a), which will be highly relevant to the empirical puzzle we focus on in this paper. Consider (23):

- (23) Nadya met [the linguist who has written any book].

This sentence is SDE with respect to $[_{NP} \text{book}]$, since for any constituent X' entailing $[\text{book}]$, the sentence in (23) will Strawson entail a sentence in which $[\text{book}]$ is substituted with X' . For example, if (23) is true, there must be a unique linguist who has written a book. If the presupposition of the sentence "Nadya met the linguist who has written a *good book*" is met, then there must exist a unique linguist who has written a good book. Note that *the linguist who has written any book* and *the linguist who has written any good book* will in this case necessarily pick out the same individual. We call this property of singular definite descriptions *uniqueness collapse*, (24): if two singular definite descriptions have restrictors which stand in a (generalized) entailment relation, and their presuppositions are defined, then they co-refer.

(24) *Uniqueness collapse:*

If $[\text{the } \phi]$ and $[\text{the } \psi]$ are defined, and $[\psi] \subseteq [\phi]$, then $[\text{the } \phi] = [\text{the } \psi]$.

The property of uniqueness collapse means that the sentence is not just SDE with respect to the restrictor of the weak NPI, but also SUE. This is because, for example, *Nadya met the student who has written a book*, and *Nadya met the student who has written a new book*, are in fact *Strawson equivalent*, since the two singular definites refer to the same individual, if their presuppositions are satisfied.

Thus, the condition in (21) successfully blocks NPIs in singular definite descriptions. Consider now (2a), repeated below as (25), we can see why the sentence with an NPI is ungrammatical: it is SUE due to uniqueness collapse.

- (25) *Katya doesn't believe [the rumor [that Anton has ever spread]].

Since for any w and any time interval τ , $\llbracket \text{rumor that Anton has spread during } \tau \rrbracket^w \subseteq \llbracket \text{rumor that Anton has spread} \rrbracket^w$, $\llbracket \text{the rumor that Anton has spread during } \tau \rrbracket^w$ and $\llbracket \text{the rumor that Anton has spread} \rrbracket^w$ will pick out the same rumor in w . This means that for any τ , the sentence *Katya doesn't believe the rumor that Anton spread during } \tau* will Strawson-entail the sentence *Katya doesn't believe the rumor that Anton spread*.

3.2 Predictions of subset vs. equality semantics

Sharvit's observation is, at its heart, about the licensing of NPIs in singular definite descriptions: it raises the question of why an NPI is possible in (27b), whereas NPIs are otherwise unacceptable in singular definite descriptions. In the previous section, we showed how the standard analysis of NPIs accounts for cases such as (26a) and (26b), due to the property of *uniqueness collapse*. The cases in (27) are challenging however — with embedded CPs, the presence of negation *does* make a difference to whether or not an NPI is licensed.

- (26) a. *Mitya believes the rumor that anyone spread.
 b. *Mitya doesn't believe the rumor that anyone spread.
- (27) a. *Mitya believes the rumor that anyone was late.
 b. Mitya doesn't believe the rumor that anyone was late.

It's important to emphasize that Sharvit's observation extends beyond just negation; we find a similar contrast between relative clauses and embedded *that*-clauses in other SDE environments, for example, in the restrictor of *every* (28a), the scope of *only* (28b) and *few* (28c), among others — in all these cases NPIs can be licensed in embedded clauses that combine with a singular definite noun phrase that is the object of *believe*.

- (28) a. Every student who believes...
 i. ... [the claim that Mary ever left] is easily fooled.
 ii. *... [the claim that Mary ever spread] is easily fooled.
- b. Only John believes...
 i. ... [the claim that Mary ever left].
 ii. *... [the claim that Mary ever spread].
- c. Few believe...
 i. ... [the claim that Mary ever left].

- ii. *...[the claim that Mary ever spread].

As we'll show in detail in the following section, both subset semantics and equality semantics incorrectly predict *both* (27a) and (27b) to be unacceptable, but for different reasons. The predictions will be the same for the environments in (28), but we'll focus on negation from here on out, for the sake of exposition. We will defer a detailed comparison with Sharvit's (2024) own conclusions until Section 6.2.

3.2.1 Subset semantics and uniqueness collapse

First, we'll show that subset semantics predicts both (27a) and (27b) to be unacceptable, because singular definite descriptions give rise to the uniqueness collapse as before. To demonstrate this prediction, let us consider definite descriptions of the form “the rumor that Q was late”. Let's take the relevant descriptions to be “the rumor that a syntactician was late”, and “the rumor that a linguist was late”, and consider what is predicted by subset semantics.

(29) *Subset semantics: predictions*

- a. Mitya doesn't believe the rumor that a syntactician was late.
- b. Mitya doesn't believe the rumor that a linguist was late.
- c. *If the presupposition of (29a) is satisfied, then:*
 $\exists!x[\text{rumor}(x) \wedge \text{CONT}(x) \subseteq \{w' \mid \text{a syntactician was late in } w'\}]$
- d. *If the presupposition of (29b) is satisfied, then:*
 $\exists!x[\text{rumor}(x) \wedge \text{CONT}(x) \subseteq \{w' \mid \text{a linguist was late in } w'\}]$
- e. *If both presuppositions are satisfied, then:*
 $\llbracket \text{the rumor that a syntactician was late} \rrbracket^w$
 $= \llbracket \text{the rumor that a linguist was late} \rrbracket^w$
- f. $\therefore$ (29a) and (29b) are Strawson-equivalent.

At the heart of the problem is the fact that subset semantics collapses “the rumor that P ” and “the rumor that P' ”, just in case $P' \subseteq P$. Because of that, it predicts examples like (27) to be bad regardless the presence of entailment-reversing operators like negation.

Nevertheless, it's important to mention that subset semantics successfully accounts for NPI-licensing in a *that*-clause embedded directly under *believe*, by rendering the local environment monotonic.

- (30) a. *Mitya believes that anyone is coming to the party.
 b. Mitya doesn't believe that anyone is coming to the party.

To see why, consider the simplified logical form of a belief report according to subset semantics, and it's negated counterpart, (31a)-(31b).

- (31) a. $\exists e \leq w[\text{believe}(e) \wedge \text{HOLDER}(e) = x \wedge \text{CONT}(e) \subseteq p]$
 b. $\neg \exists e \leq w[\text{believe}(e) \wedge \text{HOLDER}(e) = x \wedge \text{CONT}(e) \subseteq p]$

(31a) preserves the entailingness of p : given an arbitrary q s.t., $p \subseteq q$, any believing whose content entails p will also entail q . The reverse does not hold — given an arbitrary p' s.t., $p \supseteq p'$, it isn't guaranteed that if a believing's content entails p it will also entail p' . (31b), on the other hand, reverses the entailingness of p . Given an arbitrary p' s.t., $p \supseteq p'$, if there is no believing whose content entails p , it follows that there is no believing whose content entails p' . The reverse does not hold — given an arbitrary q s.t., $p \subseteq q$, just because there is no believing whose content entails p , does not mean that there is no believing whose content entails q . Therefore, the licensing condition in (21) predicts the attested judgments in (30a) and (30b).¹⁴

3.2.2 Equality semantics and non-monotonicity

Equality semantics also doesn't have the resources to capture the contrast between the pertinent examples in (27), but for a different reason: it creates an environment that is *neither SDE nor SUE*. Unlike subset semantics, it does not give rise to the uniqueness collapse. This is a consequence of the fact that, given any function f , f cannot by definition map the same individual x to distinct values, (33).

- (33) *Functionality guarantees disjoint reference:*

$$\begin{array}{l} \text{If } \exists!x \in D_\sigma[f(x) = p] \text{ and } \exists!y \in D_\sigma[f(y) = q], \text{ and } p \neq q \\ \text{then } \iota x[f(x) = p] \neq \iota y[f(y) = q] \end{array} \quad \forall f \in D_{\langle \sigma, \tau \rangle}, p, q \in D_\tau$$

Under equality semantics, CONT plays the part of f . This guarantees disjoint reference: “the rumor that a syntactician was late” and “the rumor that a linguist was late” necessarily pick out distinct entities, (34). Because of this, the sentences in (34a) and (34b) are truth-conditionally independent: neither entails the other one, even though $\llbracket \text{syntactician} \rrbracket \Rightarrow_s \llbracket \text{linguist} \rrbracket$. Thus, singular definite descriptions of the form “the rumor that P ” create *non-monotonic* environments: sentences containing them are neither SDE nor SUE with respect to indefinites inside of the embedded CP.

¹⁴ One might have a potential concern that neg-raising is crucially implicated in the licensing of NPIs in the embedded clause: a salient reading of (30b) conveys that *Mitya believes that nobody is coming to the party*. However, NPIs can be licensed in the complements of doxastic attitude predicates which don't allow for neg-raising, such as *to be certain* (see also Sharvit 2024), and so licensing NPIs cannot be contingent on neg-raising.

- (32) Mitya { * is | isn't } certain that anyone is coming.

(34) *Equality semantics: predictions*

- a. Mitya doesn't believe the rumor that a syntactician was late.
- b. Mitya doesn't believe the rumor that a linguist was late.
- c. *If the presupposition of (34a) is satisfied, then:*
 $\exists!x[\text{rumor}(x) \wedge \text{CONT}(x) = \{w' \mid \text{a syntactician was late in } w'\}]]$
- d. *If the presupposition of (34b) is satisfied, then:*
 $\exists!y[\text{rumor}(y) \wedge \text{CONT}(y) = \{w' \mid \text{a linguist was late in } w'\}]]$
- e. *If both presuppositions are satisfied, then given (33):*

$$\llbracket \text{the rumor that a syntactician was late} \rrbracket^w \neq \llbracket \text{the rumor that a linguist was late} \rrbracket^w$$
- f. $\therefore (34a) \not\Rightarrow_S (34b), \text{ and } (34b) \not\Rightarrow_S (34a).$

Note that these predictions of equality semantics *qua* (non-)monotonicity are connected to the predictions for belief reports more generally. Consider the schematic Logical Forms below — if p and q are distinct, then, by functionality (35a) and (35b) assert the non-emptiness of disjoint sets. Therefore, (35a) and (35b) are independent. As a result, equality semantics unsurprisingly fails to account for NPI licensing in negated belief reports.

- (35) a. $\exists e \leq w[\text{believe}(e) \wedge \text{HOLDER}(e) = \text{Mitya} \wedge \text{CONT}(e) = p]$
- b. $\exists e \leq w[\text{believe}(e) \wedge \text{HOLDER}(e) = \text{Mitya} \wedge \text{CONT}(e) = q]$

It follows that another point against equality semantics is that, since it fails to render belief reports monotonic, it fails to account for NPI licensing in negated belief-reports as in (36) where the verb combines with the *that*-clause directly.

- (36) Mitya doesn't believe that anyone is coming to the party.

3.2.3 Interim summary

To sum up, we have seen that neither subset semantics nor equality semantics can account for Sharvit's observation, but for different reasons. According to subset semantics, any singular definite, including those involving clausal embedding, creates an environment that is both SDE and SUE due to uniqueness collapse. Equality semantics, on the other hand, fails due to functionality — disjoint reference means that clausal embedding creates a non-monotonic environment. These results are summarized in (1).

	x believes the rumor that [____]	x doesn't believe the rumor that [____]
Subset	✓ SUE, ✓ SDE	✓ SUE, ✓ SDE
Equality	✗ SUE, ✗ SDE	✗ SUE, ✗ SDE
Goal	✓ SUE, ✗ SDE	✗ SUE, ✓ SDE

Table 1 Predictions of theories for complement clauses within definite DPs

Subset semantics of course makes better predictions for NPI licensing and monotonicity in simple belief reports, but it is difficult to see how it might be tweaked in order to account for Sharvit's observation. Furthermore, there are independent arguments against subset semantics, as discussed in Section 2.2. In what follows, we take a different path. We adopt equality semantics and propose a way to re-introduce monotonicity, while still avoiding the issue of the uniqueness collapse.

4 Proposal

The informal intuition behind our proposal is that, while (37a) and (37b) describe distinct eventualities, they stand in a systematic relationship: (37a) is *part* of (37b), because part of what it means to believe that it's raining heavily, is to believe that it's raining. We will suggest that the monotonicity of attitude verbs like *believe* is a consequence of the part-whole structure of eventualities that they describe, and how it is related to the part-whole structure of their THEMES and their CONTENTS.

- (37) a. *Mitya's believing that it's raining.*
 b. *Mitya's believing that it's raining heavily.*

There is some independent motivation for relating monotonicity/closure under entailment to part-whole structures: as we discuss in Section 4.2, we can exploit expressions concerning parthood such as “part of...” and “partially” when talking about attitudinal eventualities and their contents.

4.1 The mereological structure of eventualities

Mereology is the study of part-whole relationships in mathematics and logic, with broad applications in natural language semantics across domains such as plurality and aspect.¹⁵ A mereology is a domain of entities, equipped with a *parthood* relation $\leq$, which satisfies the axiomatic principles in (38). Our proposal will ultimately exploit the idea, common in the literature on event semantics, that eventualities have a rich mereological/part-whole structure (Bach 1986).

¹⁵ See Champollion & Krifka 2016 for an overview.

(38) *Axioms of classical extensional mereology*

- a. *Reflexivity*: $\forall x, x \leq x$
- b. *Transitivity*: $\forall x, y, z, (x \leq y \wedge y \leq z) \rightarrow x \leq z$
- c. *Antisymmetry*: $\forall x, y (x \leq y \wedge y \leq x) \rightarrow x = y$

In this section, we will argue that from the perspective of equality semantics, this is independently a necessary move for attitudinal eventualities like believings.¹⁶ Consider the schematic Logical Form again that equality semantics posits for a simple belief report like “Mitya believes that it’s raining”:

$$(39) \quad \exists e \leq w \left[\begin{array}{l} \text{HOLDER}(e) = \text{Mitya} \wedge \text{believe}(e) \\ \wedge \text{CONT}(e) = \{ w' \mid \text{it's raining in } w' \} \end{array} \right]$$

(39) should of course be compatible with Mitya simultaneously having distinct beliefs; indeed, as we discussed in Section 2.2, the only constraint that (39) places on the worlds in Mitya’s doxastic alternatives is that they are all worlds where it is raining. Intuitively, Mitya’s believing that it’s raining is merely *part* of Mitya’s believing. For a given rational agent x , we can posit an eventuality corresponding to x ’s *total beliefs*. The content of this total believing is exactly x ’s doxastic alternatives.

We assume, therefore, that believings may have non-trivial parts. Without saying more, this won’t contribute much — the action will lie in specifying exactly how the part-whole structure of eventualities relates to other properties they may have, such as (crucially for our purposes) their contents. In order to do this, it will be useful to have a notion of *informational* parthood, which we turn to in the next section.

4.2 Parts of propositions

At the heart of our proposal is the idea that we can talk about parts of pieces of information *qua* classical propositions. A strong conceptual motivation for this move comes from the fact that, at least in English, the same vocabulary is used to talk about part-whole structures in the domain of concrete individuals, as well as in the more abstract domain of content (Moltmann 2013, 2020). Consider first the sentences in (40), which involve so-called “sub-atomic quantification” over *parts* of flags. In English, existential quantification over sub-atomic parts can be expressed using the noun “part” or the adverbial “partly” (see, e.g., Wagiel 2021).

- (40) a. The flag is partly red.

¹⁶ See also Pasternak 2018a, which posits mereological structure for attitudinal eventualities for independent reasons.

Monotonicity via mereology in the semantics of attitude reports

- b. Part of the flag is red.
 $\Rightarrow$ *There is an x , s.t., x is part of the unique flag, and x is red.*

Moltmann (2013, 2020) observes that the same language is used to talk about parts of abstract, contentful entities, such as *rumors* (41), as well as parts of propositions (42).¹⁷ There are two interesting things to observe about the examples below: (i) we can talk about *parts* of informational objects, and (ii) the information conveyed by the part seems to stand in a systematic relation to the information conveyed by the whole (as reflected by the provided contexts). In general, it seems to be the case that the content of the whole is *more informative* than its parts. In other words, part of the information *that Anton snowboarded on Friday* is the (less informative) information *that Anton snowboarded*.

- (41) Context: *Mitya believes that Anton snowboarded on Friday.*
 - a. What Mitya believes is partly that Anton snowboarded.
 - b. Part of what Mitya believes is that Anton snowboarded.
- (42) Context: *there's a rumor that Anton snowboarded on Friday.*
 - a. Part of the rumor is that Anton snowboarded.
 - b. The rumor is partly that Anton snowboarded.

If we assume a classical perspective on propositions as sets of worlds, or their characteristic functions — as we have throughout this paper — this suggests the notion of parthood for propositions based on informativity, (43) (cf. Brown 2022).

- (43) *Parthood for propositions:*
 $p \leq q$ iff p is semantically entailed by q (i.e., $p \supseteq q$).

There are a couple of things to note at this juncture. First, the definition in (43) straightforwardly captures the intuition that, for example, the proposition *that it's raining* is part of the proposition *that it's raining and it's cold*, and more generally predicts that the individual conjuncts are parts of conjunctive propositions. It also has some less intuitive consequences. For example, the proposition denoted by a sentence of the form “ P or Q ” will be part of the proposition denoted by P . It certainly doesn't seem right to say that “it's raining or snowing” conveys *part* of what is conveyed by “it's raining”. As it so happens, any problematic predictions of (43) will find their counterpart in more general problems for closure under entailment. We'll put this to one side, but we will revisit this issue in Section 6.3.

¹⁷ Here, we assume that “what Mitya believes” is a free relative picking Mitya's total beliefs, that is, his doxastic alternatives.

Relatedly, although supersetthood qualifies as a partial order on the set of propositions, the set of propositions isn't a mereology as typically construed — this is due to the presence of the tautological proposition W , which acts as a bottom element — something typically ruled out by classical extensional mereology (Cham-pollion & Krifka 2016). Nevertheless, we can make use of the closely related notion of a *lattice*. Let's say that we model the set of classical propositions as the powerset of logical space $\mathcal{P}(W)$. As mentioned, the superset relation $\supseteq$ qualifies as a *partial order* ($\leq$) on $\mathcal{P}(W)$ since it is reflexive, anti-symmetric, and transitive (i.e., it satisfies the axiomatic principles in (38)). The structure on propositions induced by $\supseteq$ is illustrated by the Hasse diagram in Figure 1, which provides a comparison with a (more familiar) mereology presented as an atomic join semilattice. Thus, the lattice structure we assume for propositions is, in effect, the reverse of the typical example of the subset lattice on a powerset.

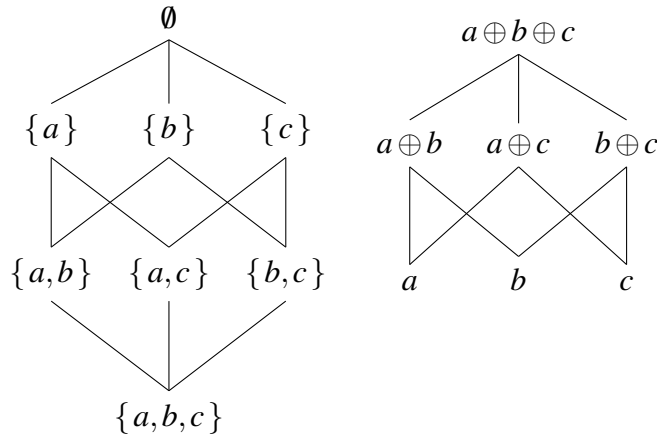


Figure 1 $\mathcal{P}(\{a, b, c\})$ as a superset lattice; $\oplus \{a, b, c\}$ as a mereology

In order to develop intuitions about this notion of parthood, let us consider a concrete example with a toy model involving a game played by Mitya (m) and Neil (n). The game can result in a tie, but only one person may win. The resulting possibilities are exhausted by w_m (Mitya is the winner), w_n (Neil is the winner), and $w_\emptyset$ (the game was a tie). The superset lattice on $\mathcal{P}(\{w_n, w_m, w_\emptyset\})$ gives rise to a notion of parthood that can be applied to complex sentences made up of the contrary statements “Mitya is the winner” and “Neil is the winner”. This is illustrated in Figure 2.

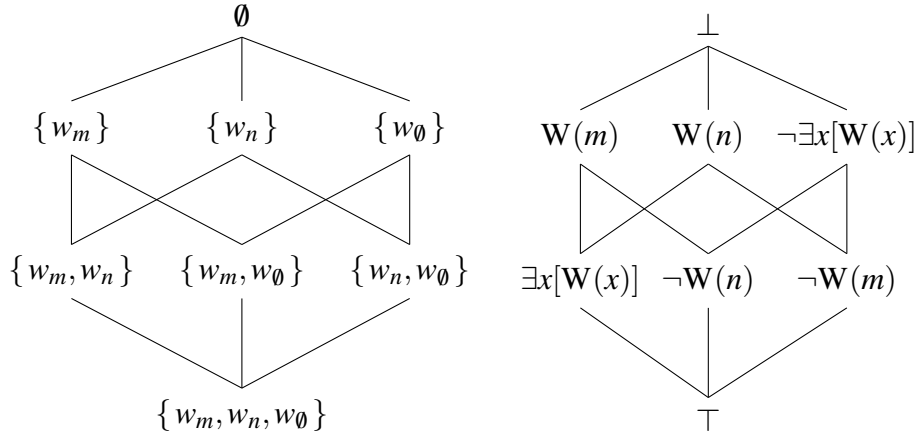


Figure 2 $W(m) := \text{Mitya is the winner}; W(n) := \text{Neil is the winner}$

The notion of parthood we assume based on informativity makes some welcome predictions. For example, it seems intuitively correct to say that *someone is the winner* $\{w_m, w_n\}$ is part of what is conveyed by both *Mitya is the winner* $\{w_m\}$ and *Neil is the winner* $\{w_n\}$. Similarly, it seems right to say that *Mitya isn't the winner* $\{w_n, w_\emptyset\}$ and *Neil isn't the winner* $\{w_m, w_\emptyset\}$ are both parts of what is conveyed by *Nobody is the winner* $\{w_\emptyset\}$.

4.3 Mapping from *beliefs* to propositions

Now that we've established a partial ordering on eventualities, based on mereological parthood, and a partial ordering on the set of propositions, based on informativity, we can state our proposal for reinstating monotonicity in equality semantics. Let's say that Mitya holds a belief e with content p , and furthermore that p has a proper part (i.e., a proposition it properly entails) p' . This necessitates the existence of a belief of Mitya's $e' < e$ with content p' . We formalize this as the condition Mapping to Sub-parts of the Input (MSI), defined in (44), which demands that the content function preserve proper parthood.

- (44) *CONT satisfies Mapping to Sub-parts of the Input (MSI):*

$$p' < \text{CONT}(x) \rightarrow \exists x' < x [\text{CONT}(x') = p'] \quad \forall x \in \text{Dom}(\text{CONT}), p' \in D_{st}$$

The condition in (44) is sufficient to reinstate monotonicity in the semantics of *believe*. In order to see this, assume, for example, that *Mitya believes p*, (45). This environment is upward entailing since any arbitrary proposition $p' \supset p$ is such that

$p' < p$, and hence MSI necessitates a corresponding believing.¹⁸ This is sufficient to guarantee that Mitya holds a belief e' with content p' . So for example, if $p = \textit{Anton has snowboarded last Friday}$, and $p' = \textit{Anton has snowboarded}$, then due to the constraint in (44), because *Anton has snowboarded* is part of *Anton has snowboarded last Friday*, the existence of a believing by Mitya that Anton snowboarded last Friday necessitates existence of a believing by Mitya that Anton snowboarded.¹⁹

(45) Mitya believes p .

- a. $\exists e \leq w[\text{HOLDER}(e) = \mathbf{M} \wedge \text{believe}(e) \wedge \text{CONT}(e) = p]$
- b. $p' < p$
- c. $\exists e' < e[\text{CONT}(e') = p']$ by MSI
- d. $\therefore \exists e' \leq w[\text{HOLDER}(e') = \mathbf{M} \wedge \text{believe}(e') \wedge \text{CONT}(e') = p']$

Conversely, MSI makes negated belief reports downward (and not upward) entailing. This is demonstrated (by contradiction) in (46). Asserting that *Mitya has no belief with content p'* is incompatible with the existence of a belief of Mitya's with content p , where $p' \supset p$. This is because positing such a p -belief, guarantees the existence of a p' -belief, by MSI.

(46) Mitya doesn't believe p' .

- a. $\neg \exists e' \leq w[\text{HOLDER}(e') = \mathbf{M} \wedge \text{believe}(e') \wedge \text{CONT}(e') = p']$
- b. $\exists e \leq w[\text{HOLDER}(e) = \mathbf{M} \wedge \text{believe}(e) \wedge \text{CONT}(e) = p]$
- c. *By the reasoning in (45),*
 $\exists e' \leq w[\text{HOLDER}(e') = \mathbf{M} \wedge \text{believe}(e') \wedge \text{CONT}(e') = p']$
- d. $\therefore$ (46c) contradicts (46a).

(44) therefore reinstates monotonicity for equality semantics, and closure under entailment is captured. This addresses one of the main objections to equality semantics, and accounts for the possibility of NPIs in negated belief reports. The next step will be to generalize this mereological approach to monotonicity to contentful THEMES of believings.

¹⁸ Note that we also importantly assume that if e is a believing of Mitya's, then every part of e is also a believing of Mitya's; this is analogous to the property of *divisive reference* often discussed in the literature on mass nouns (Cheng 1973).

¹⁹ In order to keep the proofs readable, we will adopt the convention (where it doesn't lead to ambiguity) that existentially-quantified variables are implicitly instantiated and subsequently generalized over for the purposes of subsequent proof steps.

4.4 Mapping from eventualities to objects

Sharvit’s observation involves sentences in which *believe* composes with a DP of the form *the rumor that p*. We assume that *rumors*, much like more concrete entities, have a mereological structure. In fact, MSI for CONT (44), *guarantees* that contentful entities like rumors have (proper) parts. The reasoning is the same as for believings, as discussed in the previous section. When we apply MSI to the content of a *rumor* in (47), we derive that for any part p' of the content of the rumor r , there must be a corresponding *sub-rumor* r' which has p' as its content.

(47) There’s a rumor that p .

- a. $\exists x[\text{rumor}(x) \wedge \text{CONT}(x) = p]$
- b. $p' < p$
- c. $\therefore \exists x' < x[\text{CONT}(x') = p']$

By MSI

Given that both believings, and contentful individuals like rumors have a non-trivial mereological structure, we can ask how to constrain the mapping between these two domains, given that believings can have rumors as their THEMES. We posit a similar constraint to MSI, which we call Mapping to Sub-parts of the Output (MSO). Informally, it says that if an eventuality e has a THEME, then for any sub-eventuality $e' < e$, there must be an x' , which is part of $\text{THEME}(e)$, and is e' ’s THEME. Essentially, it requires that all sub-events be mapped onto sub-THEMES.

(48) THEME satisfies Mapping to Sub-parts of the Output (MSO):

$$e' < e \rightarrow \exists x' < \text{THEME}(e)[\text{THEME}(e') = x'] \quad \forall e \in \text{Dom}(\text{THEME}), e' \in D_v$$

We ultimately suspect that (48) is not specific to believings and their THEMES, but rather that this is a special case of so called *incremental theme* verbs. In the following section, we zoom out and explore the parallels between MSO, MSI and Krifka’s (1998) work on incrementality.

4.5 The connection with incrementality

There is a compelling parallel between MSI, MSO, and Krifka’s (1998) approach to *incrementality*. One of the goals of Krifka 1998 is to characterize the relationship between the eventuality and the THEME expressed by sentences such as (49). The sentence in (49) describes Mitya’s *eating* of a plum. A common intuition in the literature is that there is a systematic relationship between the temporal parts of Mitya’s eating, and the mereological parts of the plum: Mitya’s eating *uses up* parts of the apple, as it temporally progresses. Krifka characterizes this intuition formally in (50), where f is taken to be a thematic function, such as THEME. *Mapping to*

sub-events is a property of a thematic function f just in case for any event e in its domain and any individual x' which is a proper sub-part of the individual $f(e) = x$, $x' < x$, there exists e' , which is a proper sub-part of e , with x' as its participant.

(49) Mitya ate the plum.

(50) *Mapping to sub-events* (Krifka 1998):

A partial function $f : D_v \mapsto D_e$ shows *mapping to sub-events* iff:

$$x' < f(e) \rightarrow \exists e' < e [f(e') = x'] \quad \forall e \in \text{Dom}(f), x' \in D_e$$

We can apply (50) to (49), assuming the Logical Form in (51). Since *the plum* has a non-trivial mereological structure, (50) will guarantee the corresponding proper parts of e (*Mitya's eating*) to have proper parts of *the plum* as their THEMES.

(51) $\exists e \leq w[\text{AGENT}(e) = \text{M} \wedge \text{eating}(e) \wedge \text{THEME}(e) = \iota x[\text{plum}(x)]]$

Krifka (1998) also postulates the reverse property, *mapping to sub-objects*. Applied to the sentence in (49), (52) ensures that for each proper sub-event of Mitya's eating there is a proper sub-part of the apple that is its THEME.

(52) *Mapping to sub-objects* (Krifka 1998):

A partial function $f : D_v \mapsto D_e$ shows *mapping to sub-objects* iff:

$$e' < e \rightarrow \exists x' < f(e) [f(e') = x'] \quad \forall e \in \text{Dom}(f), e' \in D_v$$

There is a tight connection between Krifka's *mapping to sub-events* and *mapping to sub-objects* and our principles MSI and MSO introduced in the previous sections. These four properties are just particular instantiations of the two general principles in (53) and (54), which govern how a function maps one structured domain to another.

(53) A function $f : D \mapsto D'$ satisfies MSI iff:

$$y' < f(x) \rightarrow \exists x' < x [f(x') = y'] \quad \forall x \in D, \forall y' \in D'$$

(54) A function $f : D \mapsto D'$ satisfies MSO iff:

$$x' < x \rightarrow \exists y' < f(x) [f(x') = y'] \quad \forall x, x' \in D$$

Krifka's proposal then says that the THEME function that applies to *eating* events exhibits both of the properties in (53)-(54). As for our proposal, it amounts to saying that the property in (53) holds of the CONT function, and that the property in (54) holds of the THEME function when applied to believings.²⁰ Thus, the principles that we proposed in (44) and (48) are not specific to *believe*, but exemplify more general principles for mapping between structured domains.

²⁰ A natural question is whether (53) holds of THEME, and relatedly whether (54) holds of CONT for believings. We think that it is plausible that the answer to these questions is positive, but leave this issue for future research.

Despite clear similarities, there is an important difference between our account of the relationship between believings and their contents and Krifka's account of incrementality of predicates like *eat*. The notion of parthood that Krifka assumes for events tracks their temporal structure: for example, for an eating eventuality *e*, the run-time of any proper part of *e* is included within the run-time of *e* itself. It is however crucial that the parthood relation that applies to believings would *not* necessarily track their temporal structure: if Mitya believes *that it's raining and it's hot* over the course of a time interval *t*, that doesn't entail that Mitya believes *it's raining* only over the course of a proper sub-interval. Similarly, if Mitya partly believes a conjunctive proposition, it doesn't mean that he is part way through the duration of a believing with the conjunctive content. Instead, we interpret (55) as saying that the content of Mitya's belief is part of the proposition *it's raining and it's hot*.

(55) Mitya partly believes that it's raining and it's hot.

Thus, the notion of parthood has to be different for predicates like *eat* and for attitudinal eventualities like believings. For believings, it must be more abstract than what is commonly assumed in work on incrementality, and is crucially not grounded in the spatio-temporal properties of the eventualities in question. We leave a more thorough investigation of the interaction between attitude verbs and incrementality for future work (but see, e.g., Zuchewicz 2020, Zuchewicz & Szucsich 2020).

4.6 Theme-Event Content Matching (TECM)

The final ingredient that we will need to account for Sharvit's observation involves the argument-structural properties of *believe*. Many attitude verbs, including *believe*, may embed both CPs and DPs. When the DP is headed by a content noun, which itself embeds a CP, some attitude verbs license an entailment pattern schematized in (56), which we call DP-to-CP entailment (Prior 1971, Vendler 1972, Ginzburg 1995, Pietroski 2000, King 2002, Moltmann 2013, Elliott 2016, Uegaki 2016, Djärv 2023).

(56) *DP-to-CP entailment*:

$$\llbracket x \text{ V } [\text{DP the NP CP}] \rrbracket \Rightarrow \llbracket x \text{ V CP} \rrbracket$$

Believe is one of the verbs that exhibits the DP-to-CP entailment, (57). Many attitude verbs however do not exhibit the DP-to-CP entailment, (58).²¹

(57) *Verbs exhibiting the DP-to-CP entailment*

²¹ Note that this distinction does not align with (non)-factivity/presuppositionality: for example, *imagine* is not presuppositional, but nevertheless lacks the DP-to-CP entailment.

- a. Katya *believes/denied/accepted/doubted/memorized/trusted/*
(dis)proved/validated/repeated [the claim that Anton snowboarded].
 - b. $\Rightarrow$ Katya *believes/denied/accepted/doubted/memorized/trusted/*
(dis)proved/validated/repeated [that Anton snowboarded].
- (58) *Verbs not exhibiting the DP-to-CP entailment*
- a. Katya *knew/recognized/recalled/forgot/discovered/imagined/judged/*
regretted/praised/saw [the claim that Anton snowboarded].
 - b. $\nRightarrow$ Katya *knew/recognized/recalled/forgot/discovered/imagined/judged/*
regretted/praised/saw [that Anton snowboarded].

It is conceivable that the DP-to-CP entailment is derived compositionally (see Uegaki 2016, Djärv 2023, a.o., for discussion). Since our proposal doesn't hinge on a particular compositional approach, we will simply assume the meaning postulate Theme-Event Content Matching (TECM) for the verbs that exhibit the DP-to-CP entailment. TECM is intended to capture the intuition that in cases like (57), the source of the DP-to-CP entailment is the requirement that the content of attitudinal eventuality being described matches the content of the contentful THEME.

- (59) *Theme-Event Content Matching (TECM):*
 TECM holds of $P \in D_{\langle v, t \rangle}$ iff:
 $P(e) \rightarrow (\text{CONT}(e) = \text{CONT}(\text{THEME}(e)))$
 $\forall e \in \text{Dom}(\text{CONT}) \cap \text{Dom}(\text{THEME})$

To illustrate how TECM derives the entailment, consider the case of *believe*. If Katya has a belief whose THEME is *the rumor that p*, (60a), the content of that rumor is *p*. By TECM, this must also be the content of Katya's believing, (61). Thus, the truth of (60b) follows directly.

- (60) a. Katya believes the rumor that *p*.
 b. Katya believes that *p*.
- (61) a. $\exists e \leq w \left[\begin{array}{l} \text{HOLDER}(e) = K \wedge \text{believe}(e) \\ \wedge \text{THEME}(e) = \iota x [\text{rumor}(x) \wedge \text{CONT}(x) = p] \end{array} \right]$
 b. $\text{CONT}(e) = \text{CONT}(\text{THEME}(e)) = p$ By TECM
 c. $\exists e \leq w [\text{HOLDER}(e) = K \wedge \text{believe}(e) \wedge \text{CONT}(e) = p]$

Since, by assumption, TECM doesn't hold for the verbs in (58), we cannot infer anything about the content of the eventuality that they describe even if we know the content of their THEME. In the following section, we will see that TECM turns out to be a crucial ingredient in our account of the Sharvit's observation, alongside with the MSI and MSO principles defined in the previous sections.

5 Accounting for Sharvit's observation

We now turn to our account of Sharvit's observation. The necessary ingredients, repeated below, are: (i) a non-monotonic equality semantics for clausal embedding, (62); (ii) MSI of the content for believings, (63); (iii) MSO for THEMES, (64), and (iv) TECM, to link up the content of a believing with its THEME, (65).

- (62) *Equality semantics for that-clauses:*
 (after Moulton 2009, Elliott 2017, Bondarenko 2022, etc.):

$$\llbracket \text{that } S \rrbracket = \lambda x_{\sigma} . \text{CONT}(x) = \{ w' \mid \llbracket S \rrbracket^{w'} = 1 \} \quad \sigma \in \{ e, v \}$$
- (63) *CONT satisfies MSI:*

$$p' < \text{CONT}(x) \rightarrow \exists x' < x [\text{CONT}(x') = p'] \quad \forall x \in \text{Dom}(\text{CONT}), p' \in D_{st}$$
- (64) *THEME satisfies MSO:*

$$e' < e \rightarrow \exists x' < \text{THEME}(e) [\text{THEME}(e') = x'] \quad \forall e \in \text{Dom}(\text{THEME}), e' \in D_v$$
- (65) *TECM:*
 TECM holds of $P \in D_{\langle v, t \rangle}$ iff:

$$P(e) \rightarrow (\text{CONT}(e) = \text{CONT}(\text{THEME}(e))) \quad \forall e \in \text{Dom}(\text{CONT}) \cap \text{Dom}(\text{THEME})$$

We take it that Sharvit's observation shows that embedded clauses in singular definite descriptions can be monotonic environments, when embedded under certain attitude verbs. As well as the NPI distribution facts, this is supported by intuitions concerning entailment: we agree with Sharvit (2024) that (66b) (Strawson) entails (66a) but not vice versa, and (67a) (Strawson) entails (67b) but not vice versa.

- (66) *Positive sentences:* $\checkmark \text{SUE}, \text{X} \text{SDE}$
- Katya believes the rumor that Anton has snowboarded.
 - Katya believes the rumor that Anton has snowboarded last Friday.
- (67) *Negative sentences:* $\text{X} \text{SUE}, \checkmark \text{SDE}$
- Katya doesn't believe the rumor that Anton has snowboarded.
 - Katya doesn't believe the rumor that Anton has snowboarded last Friday.

With all of the necessary pieces now in place, we'll first walk through how our proposal predicts that the positive sentences are SUE but not SDE. Let p and p' stand for propositions such that p is strictly more informative than p' , i.e., $p' \supset p / p' < p$. First, let's derive that (68a) Strawson-entails (68b), and the environment is thus SUE. The informal proof is given in (69).

- (68) a. Katya believes the rumor that p
 (e.g.: $p = \text{Anton has snowboarded last Friday}$).

- b. Katya believes the rumor that p' $p' < p$
 (e.g.: $p' = \text{Anton has snowboarded}$).

(69) (68a) Strawson-entails (68b)

- a. *Assumptions*
- i. $\exists e[\text{believe}(e) \wedge \text{HOLDER}(e) = K \wedge \text{THEME}(e) = r_1]$ (68a)
 - ii. $r_1 := \iota r[\text{rumor}(r) \wedge \text{CONT}(r) = p]$ *presupp. of (68a)*
 - iii. $r_2 := \iota r[\text{rumor}(r) \wedge \text{CONT}(r) = p']$ *presupp. of (68b)*
- b. $\text{CONT}(e) = \text{CONT}(r_1) = p$ TECM
- c. $\exists e' < e[\text{CONT}(e') = p']$ MSI; $p' < p$
- d. $\exists r' < r_1[\text{rumor}(r') \wedge \text{THEME}(e') = r']$ MSO
- e. $\text{CONT}(r') = \text{CONT}(e') = p'$ TECM
- f. $r' = r_2$ via uniqueness; (69a.iii)
- g. $\exists e'[\text{believe}(e') \wedge \text{HOLDER}(e') = K \wedge \text{THEME}(e') = r_2]$
generalization over e'

Let's consider how this proof works. Our goal is to show that (68b) follows if we assume the truth of (68a), together with (68b)'s presupposition (as outlined in (69a)). Concretely, we assume that there is a believing of Katya's whose THEME is the unique rumor that p , and that there is a unique rumor that p' . From TECM, Katya's believing inherits its contents p from its THEME. Since p has a proper part p' , this bootstraps reasoning via MSI that there must be a sub-believing of Katya's, e' , with content p' . Now that we established the existence of e' via MSI, this necessitates via MSO the existence of a sub-rumor r' which is the THEME of e' . TECM guarantees that the content of the sub-rumor is p' , inherited from e' . Given that we already assume that there is a unique rumor that p' , we can now conclude that there's a believing of Katya's (e') whose THEME is the rumor that p' . Thus, we successfully capture the intuition that (68a) Strawson entails (68b): a sentence like *Katya believes the rumor that Anton has snowboarded last Friday* Strawson-entails the sentence *Katya believes the rumor that Anron has snowboarded*.

Importantly, we also predict 'positive' sentences not to be SDE, (70).

(70) (68b) does not Strawson-entail (68a)

- a. *Assumptions*
- i. $\exists e'[\text{believe}(e') \wedge \text{HOLDER}(e') = K \wedge \text{THEME}(e') = r_2]$ (68b)
 - ii. $r_1 := \iota r[\text{rumor}(r) \wedge \text{CONT}(r) = p]$ *presupp. of (68a)*
 - iii. $r_2 := \iota r[\text{rumor}(r) \wedge \text{CONT}(r) = p']$ *presupp. of (68b)*
- b. $r_1 \neq r_2$ from functionality

- c. $\text{CONT}(e') = p'$ via TECM
N.b.: no guarantee of a belief with content p !

Due to equality semantics, if there is a unique rumor r_2 with content p' (70a.iii), and a unique rumor r_1 with content p (70a.ii), r_1 and r_2 are necessarily distinct (70b). Thus, Katja believing r_2 does not tell us anything about whether Katja also believes r_1 . All we can infer is that Katja believes the content of r_2 , i.e., p' . Because $p \not\prec p'$, no further conclusions about Katja's beliefs can be established.

It should be clear at this point that adding negation will reverse the direction of Strawson entailment, (71): because our 'positive' sentence was monotonic with respect to restrictors of indefinites inside the embedded CP, adding negation will reverse the entailment, making the sentence SDE and not SUE. In order to show this, we establish that (71a) Strawson entails (71b) in (72). Note that this is a proof by contradiction: assuming the truth of (71a) and (71b)'s presupposition, but the falsity of (71b), we arrive at a contradiction.

- (71) a. Katja doesn't believe the rumor that p' .
 b. Katja doesn't believe the rumor that p . $p' < p$

(72) (71a) Strawson entails (71b)

- a. *Assumptions*
 i. $\neg \exists e' [\text{believe}(e') \wedge \text{HOLDER}(e') = K \wedge \text{THEME}(e') = r_2]$ (71a)
 ii. $r_2 := \iota r [\text{rumor}(r) \wedge \text{CONT}(r) = p']$ *presupp. of (71a)*
 iii. $r_1 := \iota r [\text{rumor}(r) \wedge \text{CONT}(r) = p]$ *presupp. of (71b)*
 iv. $\exists e [\text{believe}(e) \wedge \text{HOLDER}(e) = K \wedge \text{THEME}(e) = r_1]$ (71b) is false
 b. *From (72a.iv) and the reasoning in (69)*
 $\exists e' [\text{believe}(e') \wedge \text{HOLDER}(e') = K \wedge \text{THEME}(e') = r_2]$
 c. *The conclusion in (72b) contradicts (72a.i)*
Assumption (72a.iv) must be incorrect:
 $\neg \exists e [\text{believe}(e) \wedge \text{HOLDER}(e) = K \wedge \text{THEME}(e) = r_1]$

If (71b) is false, Katja must have a belief whose THEME is the rumor that p . As we have already seen in (69), existence of such a belief implies existence of a belief by Katja whose THEME is the rumor that p' , (72b). This contradicts our assumption that (71a) is true: that Katja doesn't believe the rumor that p' . Hence, (71b) must be true whenever (71a) is, and the sentence is correctly predicted to be SDE.

Note that our proposal avoids predicting that the environment would be SUE, that is, (71b) does not Strawson entail (71a). This is again due to functionality, (73b), which prevents the truth of (71b) automatically making (71a) true.

(73) (71b) does not Strawson entail (71a)

- a. *Assumptions:*
 - i. $\neg \exists e[\text{believe}(e) \wedge \text{HOLDER}(e) = K \wedge \text{THEME}(e) = r_1]$
 - ii. $r_1 := \iota r[\text{rumor}(r) \wedge \text{CONT}(r) = p]$ *presupp. of (71b)*
 - iii. $r_2 := \iota r[\text{rumor}(r) \wedge \text{CONT}(r) = p']$ *presupp. of (71a)*
- b. $r_1 \neq r_2$ due to functionality
- c. *(73a.i) is consistent with Katya believing r_2 , because $p \not\leq p'$:*
 $\exists e' \leq [\text{believe}(e') \wedge \text{HOLDER}(e') = K \wedge \text{THEME}(e') = r_2]$

The fact that Katya does not have a belief whose THEME is the rumor that p , (73a.i), does not tell us anything about whether Katya believes the rumor that p' , (73c): because the $p \not\leq p'$.

To sum up, subset semantics captures closure under entailment for simple belief reports, but it suffers due to the property of uniqueness collapse, repeated below as (74). This issue arises for subset semantics, because for any $p' \supset p$, the meaning of *that p* is a proper subset of the meaning of *that p'* . This predicts that there should be no difference in licensing NPIs in embedded CPs compared to relative clauses, contrary to fact.

(74) *Uniqueness collapse:*

If $\llbracket \text{the } \phi \rrbracket$ and $\llbracket \text{the } \psi \rrbracket$ are defined, and $\llbracket \psi \rrbracket \subseteq \llbracket \phi \rrbracket$, then $\llbracket \text{the } \phi \rrbracket = \llbracket \text{the } \psi \rrbracket$.

Equality semantics on the other hand does not face the issue of the uniqueness collapse: for any p', p such that $p' \supset p$, the meaning of an embedded clause *that p* is disjoint with the meaning of an embedded clause *that p'* — no entity with content p can be an entity with content p' and vice versa, if $p \neq p'$. This is guaranteed by functionality of CONT. This was crucial in allowing us to construct a semantics for *x believes the rumor that p* that renders the embedded clause a monotonic environment even when it is inside a singular definite description.

Thus, we conclude that it's better *not* to build monotonicity into the semantics of the embedded clause itself: the semantics of an embedded clauses is a fundamentally non-monotonic environment, but monotonicity may be reinstated if the clause is embedded in a particular environment, for example, under the attitude verb *believe*. We made this follow from the assumption that a systematic relationship exists between the part-whole structure of believings and the part-whole structure of their contents, formalized via MSI. Monotonicity was reinstated for clauses embedded within singular definite descriptions by additionally taking into account how the part-whole structure of believings is related to the part-whole structure of their THEMES (MSO), and appealing to an independently needed constraint on how the propositional content of believings and their THEMES are related (TECM). Taken together, the interaction between these different constraints allowed us to account for Sharvit's observation.

Although we grounded MSI and MSO in part-whole structures, we'll note here there is a way of restating the fundamentals of our account without making reference to mereology. What is important is that monotonicity is not built into the semantics of embedded clauses themselves, but arises by dint of properties of believing eventualities.²² For example, a postulate that achieves the same result for believing eventualities as MSI can be stated as in (75), which simply says that a believing e with content p , guarantees the existence of a believing e' with content p' , for any $p' \subseteq p$. However, in our view, removing any reference to part-whole structures limits the intuitive appeal of our approach — on the empirical side, it fails to make a connection with the distribution of modifiers such as *partly* (as discussed in Section 4.2), and conceptually the connection to incrementality is lost (see Section 4.5).

- (75) $\forall x \in D_e, e \in D_v, p, p' \in D_{st},$
 if $\exists e[\text{believe}(e) \wedge \text{HOLDER}(e) = x \wedge \text{CONT}(e) = p]$ and $p' \subseteq p$
 then $\exists e'[\text{believe}(e') \wedge \text{HOLDER}(e') = x \wedge \text{CONT}(e') = p']$

In the following section, we discuss an outstanding question which naturally arises from the perspective on monotonicity we argue for in this paper: the issue of closure under conjunction, before turning to a comparison with Sharvit's (2024) conclusions in Section 6.2. In Section 6.3, we finish by discussing possible refinements of the notion of parthood for propositions, before concluding.

6 Extensions and open issues

6.1 Closure under conjunction

Alongside closure under entailment, a classical modal semantics for attitude report (Hintikka 1969) also gives rise to another important closure property: closure under conjunction (76), thereby accounting for intuitively valid inferences such as (77). While MSI derives closure under entailment for *believe*, it still fails to derive closure under conjunction.

- (76) *Closure under conjunction:*
 For any sentences S, S' , attitude holder x ,
 “ x believes S and x believes S' ” entails “ x believes [S and S']”.
- (77) a. Mitya believes that Jessica married an American,
 b. ...and Mitya believes that Jessica married a philosopher.
 c. $\Rightarrow$ Mitya believes that Jessica married an American philosopher.

²² We're grateful to an anonymous reviewer for pressing us to clarify this point.

Essentially, the problem lies in the fact that (77a) and (77b) are still about distinct believing eventualities. (77a) guarantees the existence of (sub-)believings corresponding to every proposition strictly weaker than *Jessica married an American*, and (77b) guarantees the existence of (sub-)believings corresponding to every proposition strictly weaker than *Jessica married a philosopher*, but MSI fails to guarantee the existence of a believing with content *Jessica married an American philosopher*. There is however an extremely natural extension of the mereological perspective which will derive closure under conjunction — concretely, we suggest the principle in (78) for summing contentful entities. (78) says that, given two contentful entities x, y , the content of their *sum* is the conjunction of their individual contents.

(78) *Summing contentful entities:*

$$\text{CONT}(x \oplus y) = \text{CONT}(x) \cap \text{CONT}(y) \quad \forall x, y \in \text{Dom}(\text{CONT})$$

Once we assume that an attitude holder's believings are closed under mereological summation, we guarantee that the existence of a believing with content p , and the existence of a believing with content q , guarantees the existence of a believing with content $p \cap q$, irrespective of the relationship between p and q , (79).

- (79) a. $\exists e \leq w[\text{HOLDER}(e) = \mathbf{M} \wedge \text{believe}(e) \wedge \text{CONT}(e) = p]$
 b. $\exists e' \leq w[\text{HOLDER}(e') = \mathbf{M} \wedge \text{believe}(e') \wedge \text{CONT}(e') = q]$
 c. $\text{HOLDER}(e \oplus e') = \mathbf{M} \wedge \text{believe}(e \oplus e')$ by closure under summation
 d. $\text{CONT}(e \oplus e') = \text{CONT}(e) \cap \text{CONT}(e') = p \cap q$ by (78)
 e. $\therefore \exists e''[\text{HOLDER}(e'') = \mathbf{M} \wedge \text{believe}(e'') \wedge \text{CONT}(e'') = p \cap q]$

An interesting consequence of this proposal is that, without further ado, it can be used to account for (certain cases of) what Pasternak (2018a,b) calls *non-distributive belief ascriptions* (see also Haslinger & Schmitt 2021, Flor 2023). Non-distributive belief ascriptions involve cases where a belief can be ascribed to a plural attitude holder, without necessarily being ascribed to the atomic individuals that make up the plurality. Consider the following example from Pasternak 2018a: p. 548.

- (80) Context: *Paul just got married, and his cousins Arnie and Beatrice, who have never met, just caught wind of it. Arnie suspects that Paul's husband is rich, and has no other relevant opinions. Beatrice thinks he's a New Yorker, and has no other relevant opinions.*

Paul's cousins think that he married a rich New Yorker.

As Pasternak points out, when a belief report has a plural holder, the content of the believing can be understood as the conjunction of what the atomic individuals

believe. This is exactly what we expect if (a) believings are closed under summation, and (b) on the propositional side, summation corresponds to conjunction.²³

6.2 Comparison with Sharvit (2024)

In this section, we contextualize our paper’s contribution in relation to Sharvit 2024, where the NPI licensing facts we analyzed in Section 5 were (to our knowledge) first noted. Sharvit (2024) has a distinct goal from the current work: while we are primarily concerned with the question of how best to integrate monotonicity into a content-based framework, Sharvit’s paper is concerned with whether a content-based framework should be preferred to a more classical Hintikka framework. On the latter view, attitude verbs have a modal semantics, and take embedded clauses — which are taken to denote propositions — as their arguments.

Sharvit discusses in detail how the content-based framework is able to account for the obligatoriness/optionality of argument realization. Simplifying somewhat for the sake of exposition, Sharvit entertains an interface principle *theta-realization*, which roughly says the following: a verb, describing an eventuality e , may presuppose that e has certain thematic participants. Every presupposed thematic participant must be syntactically realized as a distinct phrase. This relates to clausal embedding in the following way: consider the contrast in (81) — *groan* may optionally compose with an embedded clause, whereas *believe* obligatorily composes with an embedded clause. This can be made to follow from theta realization, if the verb *believe* presupposes that its eventuality argument $e \in \text{dom}(\text{CONT})$, whereas *groan* does not. Note that Sharvit assumes that CONT is ‘thematic’ in the relevant sense, and (crucially, the case of *believe*) that a THEME may proxy the the CONT role.

- (81) a. Mitya groaned (that it’s raining again).
 b. Mitya believes *(that it’s raining again).

Turning to the NPI data, Sharvit considers a number of ways of capturing the intuition that (82a) Strawson entails (82b) — recognizing that this is central to accounting for the NPI facts. Sharvit considers a number of ways of making this follow on the kind of content-based view of clausal embedding we have assumed in this present work. We won’t give an exhaustive summary here, but the most salient move Sharvit considers for our purposes involves effectively building closure under entailment into what it means to be the THEME of a believing, as a presupposition. This is highly reminiscent of our TECM, together with MSI and MSO.

²³ Pasternak (2018a) argues that when the beliefs of the members of a plurality are incompatible, their plural belief can be reported using a disjunction (see also Pasternak 2018b and Marty 2019 for critical discussion). If this is correct, the principle in (78) will need refinement, as it predicts that if x and y have contrary beliefs then their plural belief should be trivial.

- (82) a. Mitya believes the claim that it's raining heavily.
 b. Mitya believes the claim that it's raining.

Sharvit however doesn't endorse this move wholesale, due to problems relating to the principle of theta-realization. The problems require consideration of another class of embedding predicates such as *reject*, which according to Sharvit, allow for DP arguments but may not embed clauses, but which nevertheless license NPIs in clauses combining with their nominal argument.²⁴ Sharvit's point is that, if *reject* does not tolerate a clausal complement, from the perspective of theta-realization, it should necessarily presuppose that *rejecting* eventualities are contentless. As Sharvit (2024) shows in detail, this is in tension with the building closure under entailment into what it means to be a THEME, thus sacrificing an account of NPI licensing in the case of (84b). We refer the interested reading to Sharvit's paper for details.

- (84) a. *Ted rejects that Mia has been happy. (Sharvit 2024: p.855)
 b. Mitya rejected the claim that Anton has ever snowboarded.

We agree with Sharvit that *rejecting* eventualities are contentless — independently, the nominal counterpart *rejection* does not behave as a content noun. It's therefore useful to assess whether our account of SDEness extends to cases such as *reject*. Concretely, we can ask whether (85a) Strawson entails (85b). This indeed doesn't follow straightforwardly from our account, if *rejecting* eventualities are treated as primitives, since our account of *believe* leans on TECM. What seems to be necessary is an additional closure property for rejecting eventualities — namely, the rejection of a contentful individual x necessitates rejections of any x' that x is part of. We leave it to future work to assess whether or not a rich mereological structure and corresponding closure properties for *rejectings* can be independently motivated, along similar lines to our analysis of the case of 'believe', in a way that is consistent with theta-realization.

- (85) a. Mitya rejected the claim that it's raining.
 b. Mitya rejected the claim that it's raining heavily.

Stepping back, it's important to note that it is an open question whether the principle of theta realization is sufficient for modeling selectional variability. Treating

²⁴ It seems to us that there are exceptions to the selectional variability reported in Sharvit 2024. A naturally occurring example where *reject* composes with a CP is given in (83). This merits further empirical investigation.

(83) "I reject that he assaulted Kendra Webdale because he had it in for women. That's an absurd notion for a person as psychotic as him." (<https://web.archive.org/web/20231230232437/https://www.nytimes.com/1999/10/20/nyregion/prosecutors-press-theory-that-killer-hates-women.html>)

embedded clauses as being semantically *modifiers* does not necessarily mean that they are syntactically adjuncts. It would be, for example, coherent to treat a *that*-clause composing with *believe* as a semantic modifier, as syntactic complement. This leaves open the possibility that selectional variability may be treated as a phenomenon with an irreducibly syntactic component, which is indeed perhaps the more standard view in the literature (see, e.g., Grimshaw 1979).

Moreover there are many independent considerations motivating the content-based framework beyond selectional variability. For example, the significant cross-linguistic evidence that the source of modal displacement in an attitude report is encoded within the embedded clause rather than embedding predicate. In languages like Navajo (Bogal-Allbritten 2016), Buryat (Bondarenko 2020) and Korean (Moulton, Bogal-Allbritten & Shimoyama 2020, Bogal-Allbritten, Moulton & Shimoyama 2024, Bondarenko 2025b) we see overt morphology in embedded clauses corresponding to the content function. In English, harmonic attitudes provide an additional argument for severing modal displacement from the attitude verb (Kratzer 2013a). Consider (86):

(86) Ralph advised that Ortcut should turn himself in.

Kratzer (2013a) observes that (86) does not involve a doubly-modal meaning: the sentence conveys that *Ortcut turns himself in, in all worlds that are compatible with the content of Ralph's advice*. This is surprising on the view that *advise* itself is modal, but consistent with the idea that the source of displacement is always inside the embedded clause. While usually the element introducing displacement is null, in cases like (86) we may conjecture that *should* functions as such a displacement-introducing element.

As discussed by Sharvit, the alternative to the content-based framework for attitude reports is the classical Hintikka view. On this view, attitude verbs and content nouns are lexically specified as taking propositional arguments. In order to account for selectional variability, for example, in the case of ‘believe’ which allows for either a CP or a DP complement, two lexical entries must therefore be posited: *believe_{DP}* and *believe_{CP}*. This view faces an important empirical challenge: it incorrectly predicts that sentences involving coordination such as (87) will be ungrammatical. If *believe_{DP}* and *believe_{CP}* are two distinct lexical items, there is no single verb ‘believe’ that is compatible with both conjuncts.²⁵

(87) Mary is gullible — she believes both [_{CP} that Bill is getting married],
and [_{DP} the rumor about him that Sally is spreading].

²⁵ Note that if (87) involves Conjunction Reduction with VP conjunction, as opposed to true CP and DP coordination, eliding the verb *believe* in the second VP would require the two verbs in the two VPs to be identical, and thus (87) still constitutes an argument against lexical ambiguity.

To sum up, we believe there are reasons to pursue the content-based approach to clausal embedding that are completely independent of a particular view of selectional variability. Thus, it is worthwhile asking how exactly monotonicity could be captured within this approach. In this paper we attempted to provide an answer for predicates like *believe*. In the future, it will be important to investigate further how the mereological approach can be adapted to predicates of other sorts, including verbs like *reject*.

6.3 Informational parthood revisited

In this paper, we adopted a simple notion of *parthood* for propositions based on informativity, repeated below in (88).

- (88) *Parthood for propositions:*
 $p' \leq p$ iff p' is semantically entailed by p (i.e., $p' \supseteq p$).

We chose to define parthood in this way essentially to cleave as closely as possible to the predictions of a classical, Hintikka approach to clausal embedding — in particular to derive *closure under entailment*, repeated below in (89).

- (89) *Closure under entailment:*
 For any sentences S, S' , attitude holder x ,
 if S entails S' , then “ x believes S ” entails “ x believes S' ”.

The notion of informational parthood in (88) however, does not always match up with our intuitions. It seems that there are certain cases where, despite the fact that $p' \supset p$, it doesn't not seem right to say that p' is *part of* p . Consider, for example, the contrast between the felicity of (90a) vs. (90b) in the provided context. Parthood *qua* classical entailment makes good predictions for (90a), but poor predictions for (90b), which is expected to be equally natural in the provided context, due to the fact that *Jessica married an American philosopher* (classically) entails that *Jessica married a linguist or a philosopher*.

- (90) Context: *Mitya believes that Jessica married an American philosopher.*
- a. What M. believes is partly that J. married an American.
 - b. #What M. believes is partly that J. married a linguist or a philosopher.

Intuitively, it seems that what distinguishes the two cases is that (90a) — the good case — involves reasoning via conjunction elimination, whereas (90b) — the bad case — involves reasoning via disjunction introduction. Classical entailment, however, provides no way of distinguishing between these two cases. This problem is highly reminiscent of the problem of logical omniscience, and (we suspect)

intrinsically linked to it. Both the classical Hintikka account of closure under entailment, and our mereological account, predict that (91a) should entail (91b), however it does not seem that we really infer (91b) from (91a).²⁶

- (91) a. Mitya believes that Jessica married an American philosopher.
b. Mitya believes that Jessica married a linguist or a philosopher.

Although we will leave a more thorough exploration of this problem to future work, we will tentatively suggest the possibility that informational parthood can be defined via a more restrictive notion of entailment, which we call *conjunctive parthood*, following Fine 2017c,b (see also Yablo 2014, Moltmann 2025, a.o.). Formulating this notion of entailment minimally requires shifting to a non-classical semantics for disjunction, according to which disjunctive sentences semantically introduces *alternatives*. There are various prominent frameworks which provide a suitable semantics for disjunction, such as truthmaker semantics (Fine 2017c,a,b, Yablo 2014), and inquisitive semantics (Ciardelli 2009, Ciardelli, Groenendijk & Roelofsen 2018). Here we will make use of *alternative semantics* (Hamblin 1973, Kratzer & Shimoyama 2017) for simplicity of exposition.

In alternative semantics, sentences express *sets* of classical propositions. In (92) we give a toy example of how simple sentences may be mapped to their alternative-semantic values (via [.]) in terms of their ordinary semantic values. In general, the denotation of a simple sentence is just the singleton set containing the proposition it expresses (92a). Conjunctive sentences follow this general rule (92b). The crucial move is the idea that disjunctive sentences denote non-trivial sets of *alternative* propositions, corresponding to each of the disjuncts (92c). Negation ‘closes off’ any alternatives, by first taking their union, and returning the singleton set of the negation of the resulting proposition (92d).

(92) *Alternative semantics*

- a. $[S] := \{ \llbracket S \rrbracket \}$
b. $[S \text{ and } S'] := \{ \llbracket S \text{ and } S' \rrbracket \}$
c. $[S \text{ or } S'] := \{ \llbracket S \rrbracket, \llbracket S' \rrbracket \}$
d. $[\text{not } S] := \{ W - \bigcup [S] \}$

With the additional structure afforded by alternatives, we can define a more restrictive notion of entailment alongside the classical notion. We’ll use $Q, Q', \dots$

²⁶ There is a ready alternative explanation for the perceived lack of entailment in (91). Via Gricean reasoning reason, (91b) plausibly implicates that *it’s not the case that Mitya believes that J. married a philosopher*, which contradicts (90a), as Rothschild (2017) points out. It’s however not clear how this reasoning could be extended to the case in (90b).

as variables over *sets of classical propositions*, which provide the relevant notion of content in alternative semantics. Classical entailment is defined as in (93): we render any additional structure provided by alternative sets inert by taking the grand union of each alternative set. Conjunctive parthood is sensitive to the additional structure afforded by alternative sets: an alternative-set Q' is a *conjunctive part* of an alternative set Q , just in case every alternative in Q classically entails an alternative in Q' , and every alternative in Q' is classically entailed by an alternative in Q .²⁷

- (93) *Classical entailment in alternative semantics:*
 Q semantically entails Q' iff $\bigcup Q \subseteq \bigcup Q'$ $\forall Q, Q' \subseteq \mathcal{P}(W)$
- (94) *Conjunctive parthood:*
 Q' is a conjunctive part of Q iff
 $\forall p \in Q, \exists p' \in Q', p \subseteq p'$ and $\forall p' \in Q', \exists p \in Q, p \subseteq p'$ $\forall Q, Q' \subseteq \mathcal{P}(W)$

Let's see what this accomplishes. It's easy to see that *it's raining* is a conjunctive part of *it's raining heavily*, since when Q and Q' are singleton sets, conjunctive parthood is equivalent to classical entailment. Conjunctive parthood does some interesting work once disjunction is involved — concretely, in alternative semantics, a sentence of the form S or S' is not a conjunctive part of S , even though it is semantically entailed by S . To see this, we walk through in (95) why *Jessica married a linguist or philosopher* (Q') is not a conjunctive part of *Jessica married an American linguist* (Q). The reason is simple — the alternative introduced by the *philosopher* disjunct isn't entailed by any alternative in Q .

- (95) $Q' := [\text{Jessica married a linguist or philosopher}]$
 $= \{ \underbrace{[\text{J. married a linguist}]}_{p_1}, \underbrace{[\text{J. married a philosopher}]}_{p_2} \}$
 $Q := [\text{Jessica married an American linguist}]$
 $= \{ \underbrace{[\text{J. married an American linguist}]}_{p_3} \}$
- a. $p_3 \subseteq p_1$
 - b. $p_3 \not\subseteq p_2$
 - c. $\exists p' \in Q', p \in Q, p \not\subseteq p'$
 - d. $\therefore Q'$ is not a conjunctive part of Q

We can now reformulate *parthood for propositions*, assuming that alternative semantics provides the relevant notion of content. This has the advantage of immediately capturing the infelicity of (90b).

²⁷ This is Fine's notion of *conjunctive parthood* translated into the alternative-semantic framework (see also Yablo 2014).

Monotonicity via mereology in the semantics of attitude reports

- (96) *Parthood for propositions (alternative semantics):*
 $Q' \leq Q$ iff Q' is a conjunctive part of Q .

It also captures the intuitive lack of entailment in (91). Recall that at the heart of our proposal is the condition repeated in (97), here modified to accommodate the shift in perspective to alternative semantics: we assume that the content of a contentful event or individual is an alternative set, rather than a set of worlds.

- (97) *CONT satisfies MSI (alternative semantics):*
 $Q' < \text{CONT}(x) \rightarrow \exists x' < x [\text{CONT}(x') = Q']$
 $\forall x \in \text{Dom}(\text{CONT}), Q' \subseteq \mathcal{P}(W)$

(97) introduces the requirement that, given a contentful x , every *proper conjunctive part* Q' of its content is the content of some sub-part of x . Since the alternative set expressed by *Jessica married a linguist or philosopher* is not a proper conjunctive part of *Jessica married an American linguist*, having a belief with the content *Jessica married an American linguist* does not necessitate having a (sub)-belief with the content that *Jessica married a linguist or a philosopher*.²⁸

Thus, the notion of conjunctive parthood seems like a promising refinement that could address some of the problems that the classical notion of entailment suffers from. We leave its more detailed exploration to future work.

7 Conclusion

In this paper, we developed a new perspective on monotonicity of attitude verbs, focusing on the case of *believe*. Our account naturally implies that what distinguishes monotonic attitude verbs like *believe* from non-monotonic attitude verbs, is whether or not *CONT* is subject to *MSI*. For believings, *CONT* is subject to *MSI*, which means that for any proper part of the content of a believing there is a corresponding proper sub-believing. For example, if Katya has a *belief that Anton snowboarded last Friday*, she also must have a (sub-)belief that *Anton snowboarded*, since the proposition that *Anton snowboarded* is a proper part of the proposition that *Anton snowboarded last Friday*. This account does away with the idea that monotonicity is linked to the presence of a universal modal in the semantics of sentences with clausal

²⁸ Yablo (2014) already made the connection between conjunctive parthood and propositional attitudes when discussing *agreement*. He argues that x and y agree on p iff p is a conjunctive part of the content of each of their beliefs. This captures the fact that in (98) we judge (98a) as true but (98b) as false.

- (98) Context: *Mitya thinks Jessica married an American linguist, Neil thinks Jessica married an American philosopher.*
 a. [True]: Mitya and Neil agree that Jessica married an American.
 b. [False]: Mitya and Neil agree that Jessica married a linguist or a philosopher.

embedding. Instead, it arises as a consequence of how the part-whole structure of an attitudinal eventuality relates to the part-whole structure of its content.

If this proposal is on the right track, then the content-based approach to clausal embedding (Kratzer 2006), and in particular the implementation in terms of equality (Moulton 2009, Elliott 2017, 2020, Bassi & Bondarenko 2021, Bondarenko 2022) seems like a very viable approach to the semantics of attitude reports and clausal embedding more generally. Among its virtues are: (i) a uniform semantics for *that*-clauses that occur in different syntactic environments, (ii) good predictions about the impossibility of stacking embedded CPs, and (iii) good predictions concerning how embedded clauses interact with definiteness. In this paper we have shown that it also allows for a straightforward account of the puzzling NPI licensing facts about CPs that modify nouns inside of singular definite descriptions under *believe* (Sharvit 2024), once we incorporate independently motivated principles governing properties of the THEME of a believing.

In this paper, we have not discussed in detail how to extend our account to predicates beyond *believe*. While there is still much work to be done in this regard, here we provide some provisional evidence that this is feasible. For any given attitude verb, we predict the following preconditions for NPI licensing in Sharvit's configuration: closure under entailment, and capacity to take a THEME argument, whose interpretation is conditioned by MSO and TECM. Verbs which we suspect follow this general pattern include *accept* and *trust*. (99a) demonstrates closure under entailment, and (99b) demonstrates TECM for these verbs. Suggestively, NPIs are judged to be acceptable in Sharvit's configuration.

- (99) a. John accepts/trusts that it's raining heavily,
 #but he doesn't accept/trust that it's raining.
 b. John accepts/trusts the claim that it's raining.
 ↗ John accepts/trusts that it's raining.
- (100) Mitya doesn't accept/trust the rumor that Anton has ever been skiing.

If any of these preconditions fail, then NPIs shouldn't be licensed in Sharvit's configuration. Consider the case of *remember* and *imagine*: while (101a) shows that *remember/imagine*-reports are closed under entailment, (101b) indicates that such reports do not exhibit TECM. As expected, NPIs are judged to be unacceptable in Sharvit's configuration adapted to these verbs.

- (101) a. John remembers/is imagining that it's raining heavily,
 #but he doesn't remember/isn't imagining that it's raining.
 b. John remembers/is imagining the claim that it's raining.
 ↘ John remembers/is imagining that it's raining.

- (102) *John doesn't remember/isn't imagining the claim that Anton has ever been snowboarding.

The intuitions reported here are at this stage only suggestive, and there is much more empirical and theoretical work to be done in extending our approach to monotonicity in belief reports to other attitude verbs.

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Tatiana Bondarenko
Harvard University
Boylston Hall, office #318
Cambridge, MA 02138
USA
tbondarenko@fas.harvard.edu

Patrick D. Elliott
Heinrich-Heine Universität Düsseldorf
Universitätsstraße 1
40225 Düsseldorf
Germany
patrick.d.elliott@gmail.com